

Methods and System Design of the FOI Information Fusion Demonstrator – IFD03

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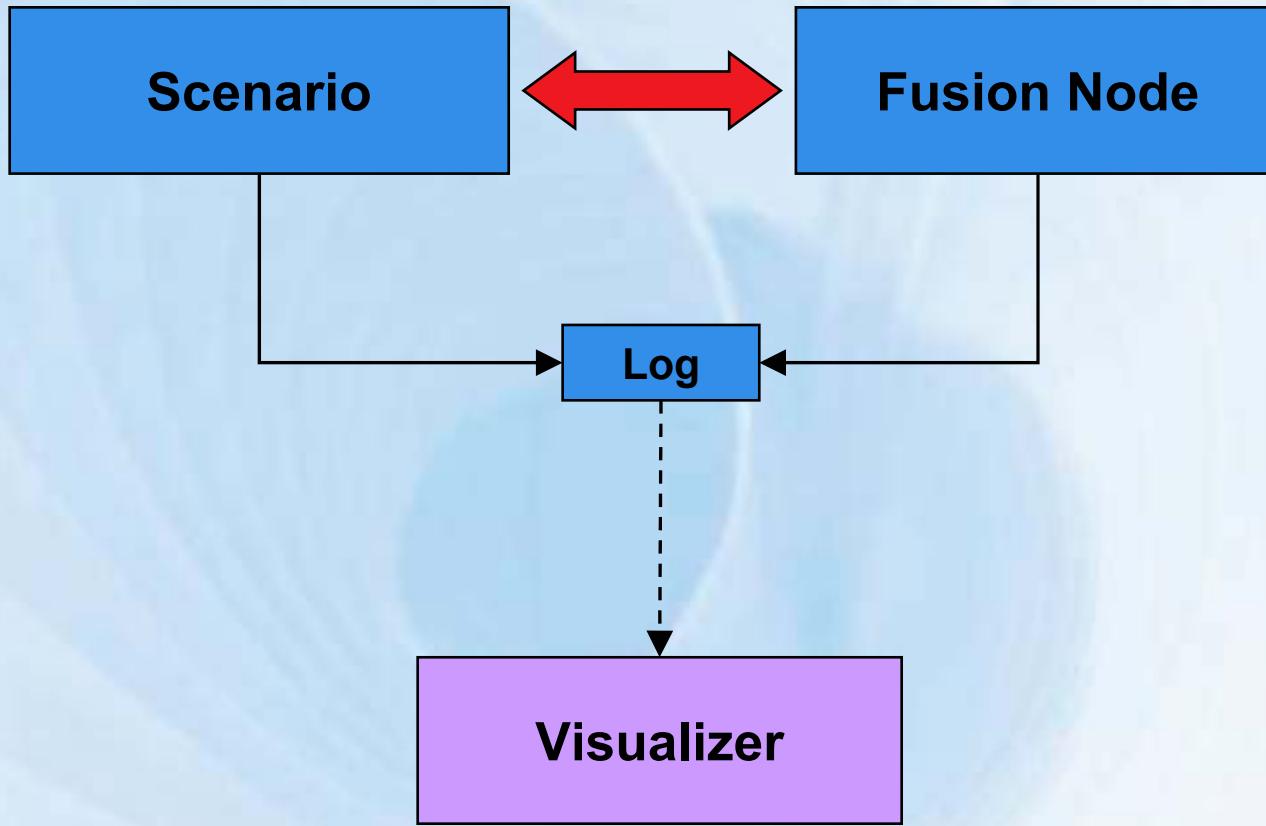
Report Documentation Page			<i>Form Approved OMB No. 0704-0188</i>	
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1. REPORT DATE SEP 2004	2. REPORT TYPE	3. DATES COVERED 00-00-2004 to 00-00-2004		
4. TITLE AND SUBTITLE Methods and System Design of the FOI Information Fusion Demonstrator - IFD03 (Briefing Charts)		5a. CONTRACT NUMBER		
		5b. GRANT NUMBER		
		5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S)		5d. PROJECT NUMBER		
		5e. TASK NUMBER		
		5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Swedish Defence Research Agency, Data and Information Fusion, SE-172 90 Stockholm, Sweden, ,		8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)		
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited				
13. SUPPLEMENTARY NOTES The original document contains color images.				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 23
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified		19a. NAME OF RESPONSIBLE PERSON

Outline

- **Introduction**
- **Information Fusion Methods**
 - Force Aggregation
 - Tracking
 - Sensor Resource Management
- **System Description**
- **Conclusion**

Introduction

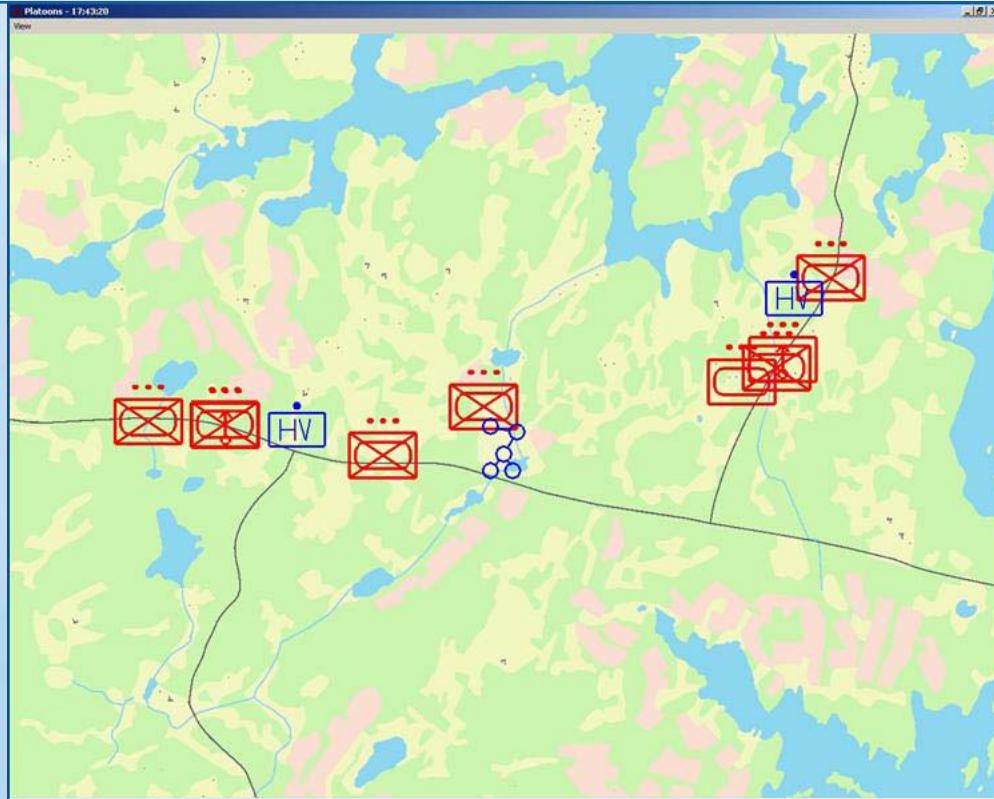
- **What is the IFD03?**
 - A *concept demonstrator* for information fusion methodology in a future Network Based Defence C4ISR system
 - Focus on analysing intelligence reports at the division level in a ground warfare scenario
- **Reasons for building the IFD03**
 - Explore how fusion methods can be combined in a single system
 - Show information fusion in a concrete fashion to our customers



Information Fusion Methods

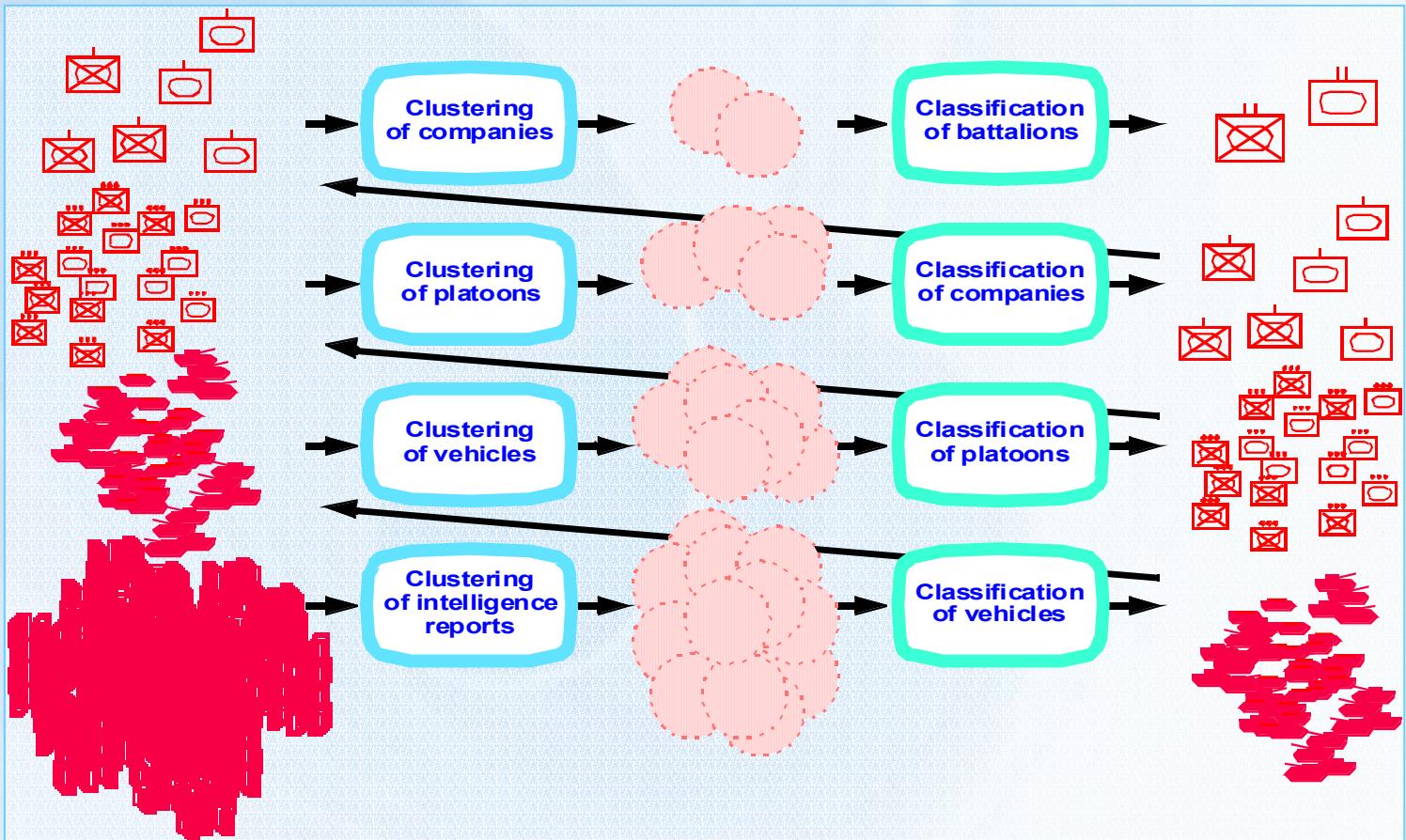
- Force Aggregation
 - Clustering
 - Classification
- Ground Vehicle Tracking
 - PHD Particle Filter
- Sensor Resource Management
 - Random Set Simulations

Force Aggregation



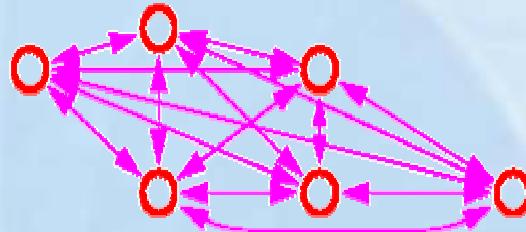
- **PROBLEM:** Determine positions and organizational structures of enemy units
- **SOLUTION:** Dempster-Shafer Clustering and Classification

Aggregation = Clustering + Classification



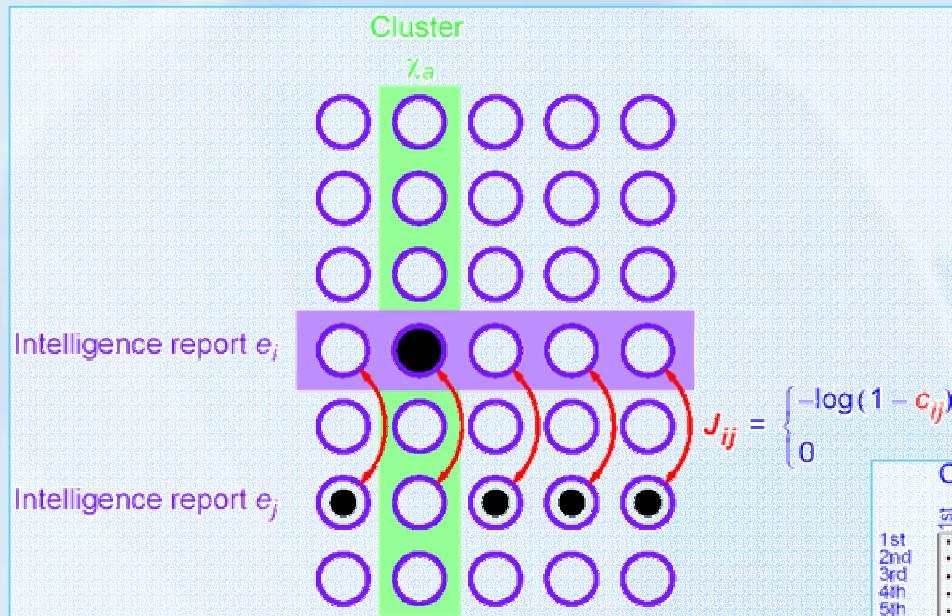
Clustering

- Evaluate all pairs of intelligence reports

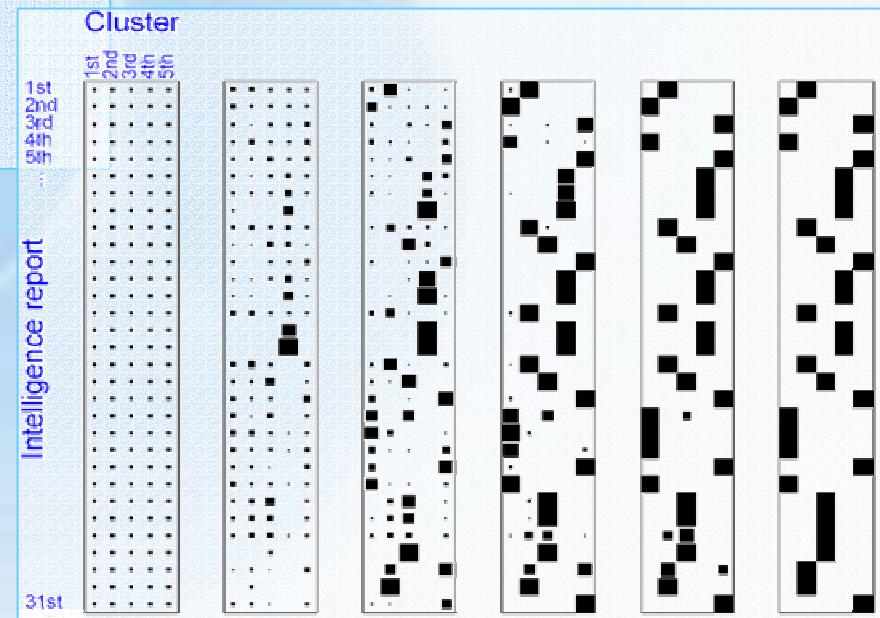


- Find whatever is against that two reports are referring to the same object
 - Wrong type of vehicle? (Dempster-Shafer conflict)
 - Is distance too long?
 - Wrong direction?
- this yields a potential conflict between each pair of intelligence reports

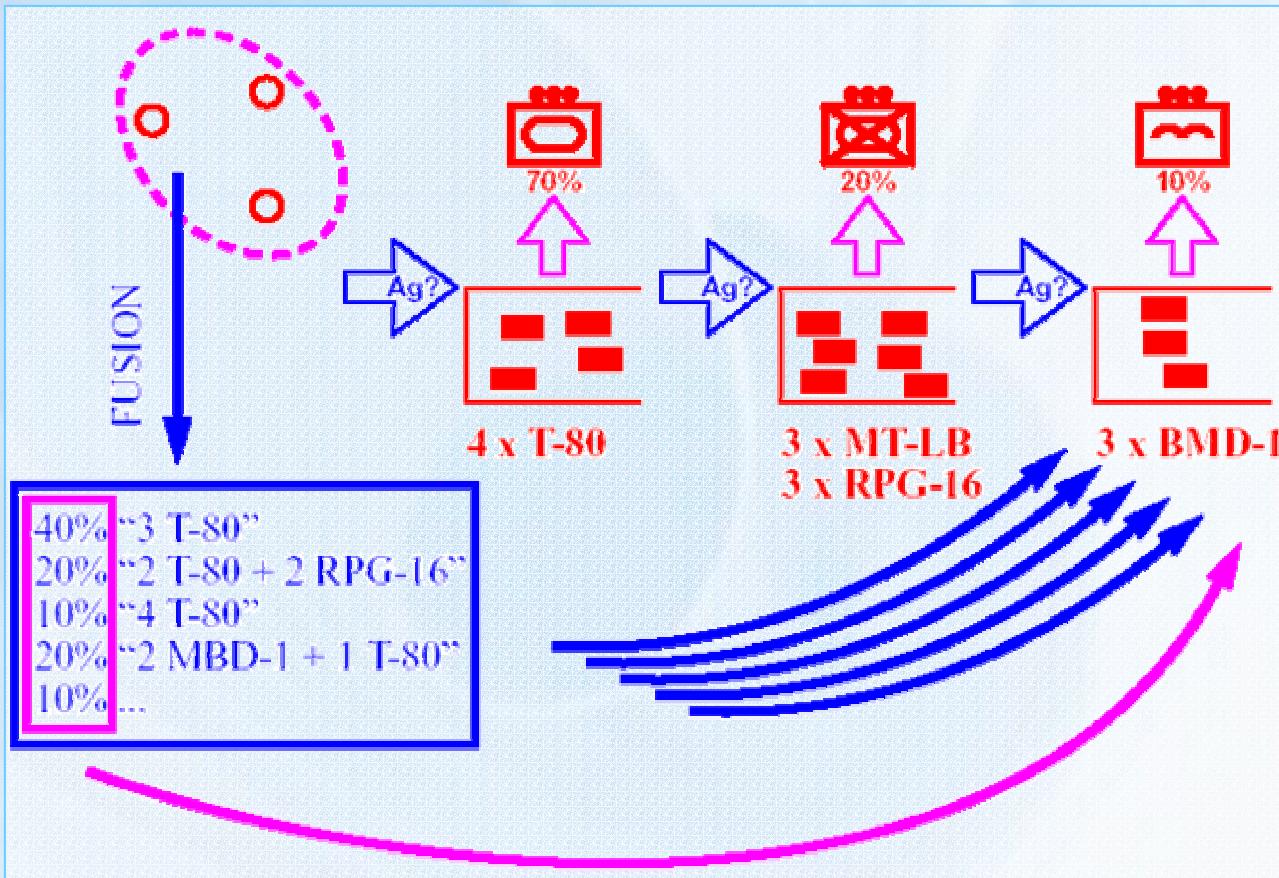
Clustering - Potts Spin neural network



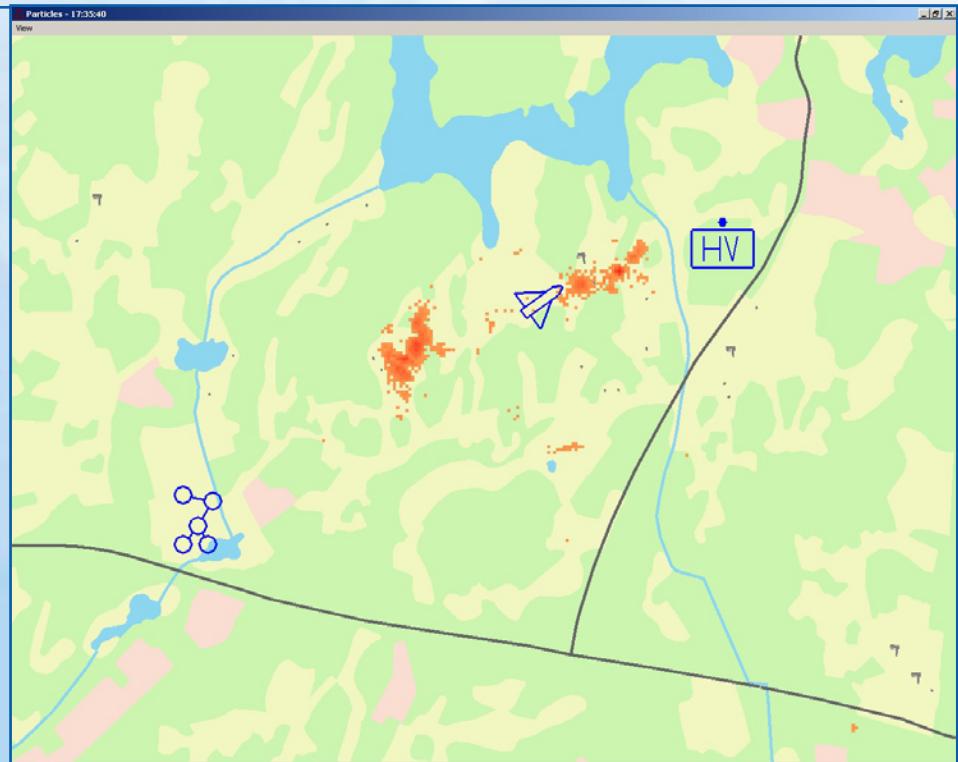
Cluster example:
31 intelligence reports are
clustered into 5 clusters



Classification



Ground Vehicle Tracking



- **PROBLEM:** Tracking of a large number of vehicles in terrain from incomplete observations.
- **SOLUTION:** PHD Particle Filtering
(PHD = Probability Hypothesis Density)

PHD Particle Filtering – Approach

- We track the first moment of joint distribution, i.e., PHD
 - Integral of PHD over an area is expected # targets – compare with PDF with integral 1
 - Avoids combinatorial explosion – good for large number of vehicles
- Here – particle filter implementation
 - No need for analytical motion and observation models
 - Suitable for non-linear problems

PHD Particle Filtering – Illustration

- A PHD is represented by $N \times 500$ particles
- N is expected number of targets

Posterior at $t-1$

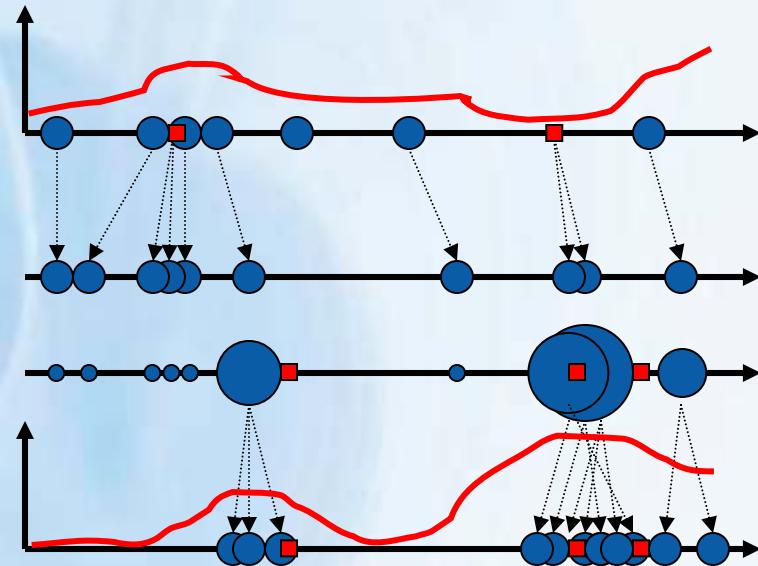
Propagate

Prior at t

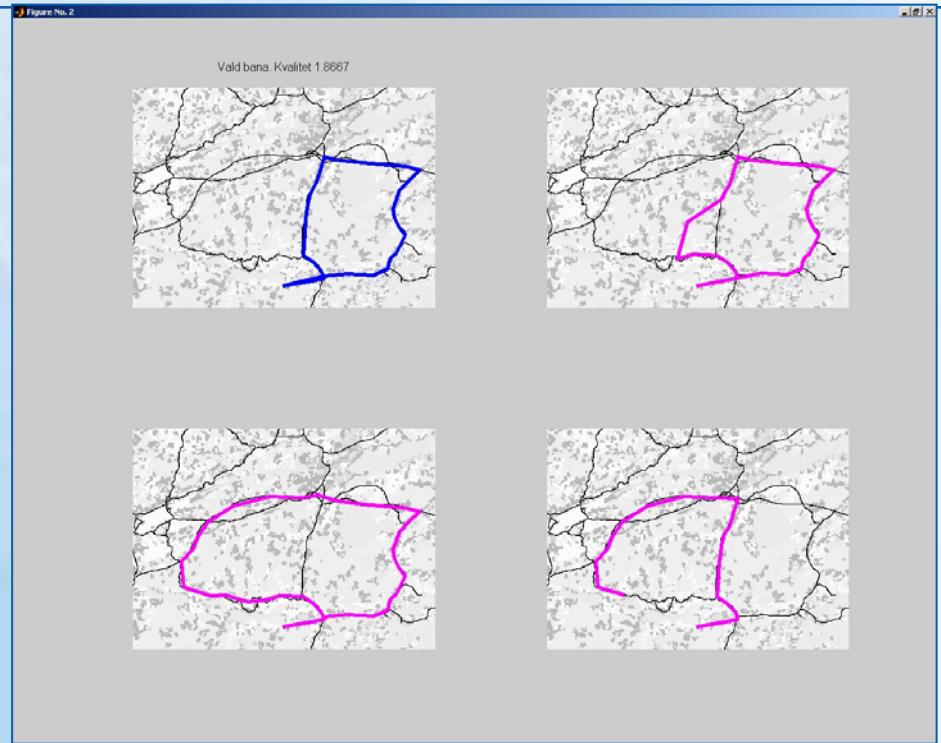
Multiply with SUM of likelihoods

Resample

Posterior at t

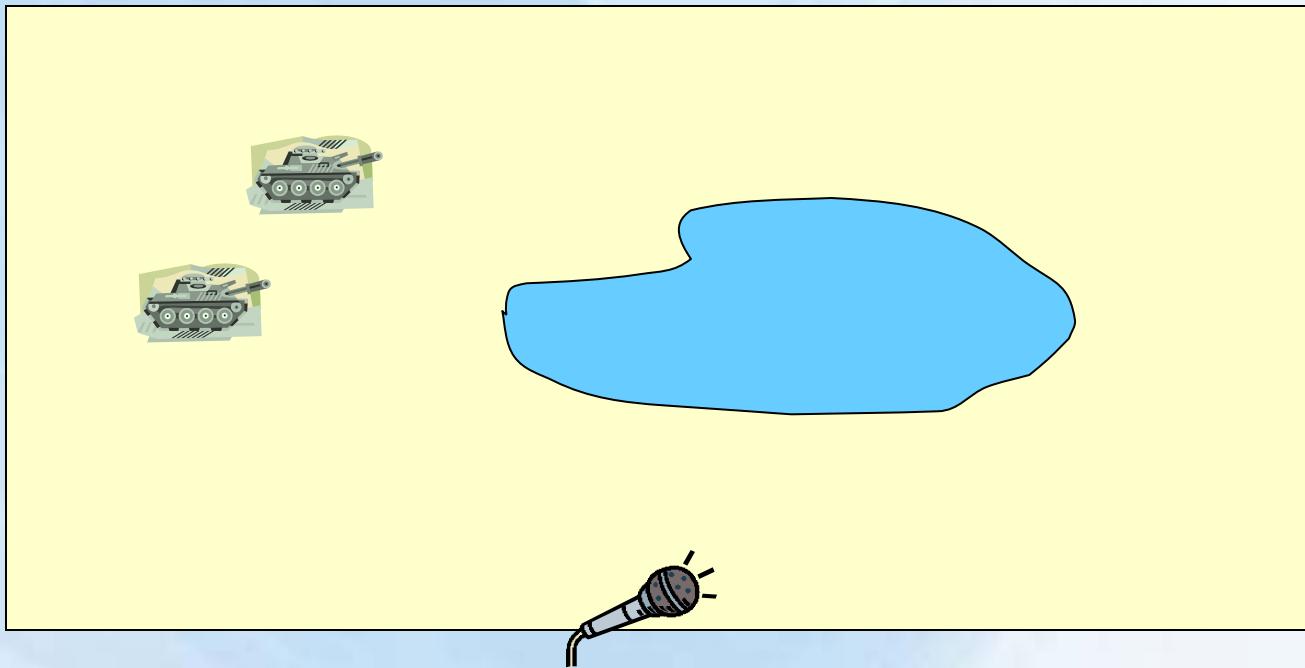


Sensor Resource Management

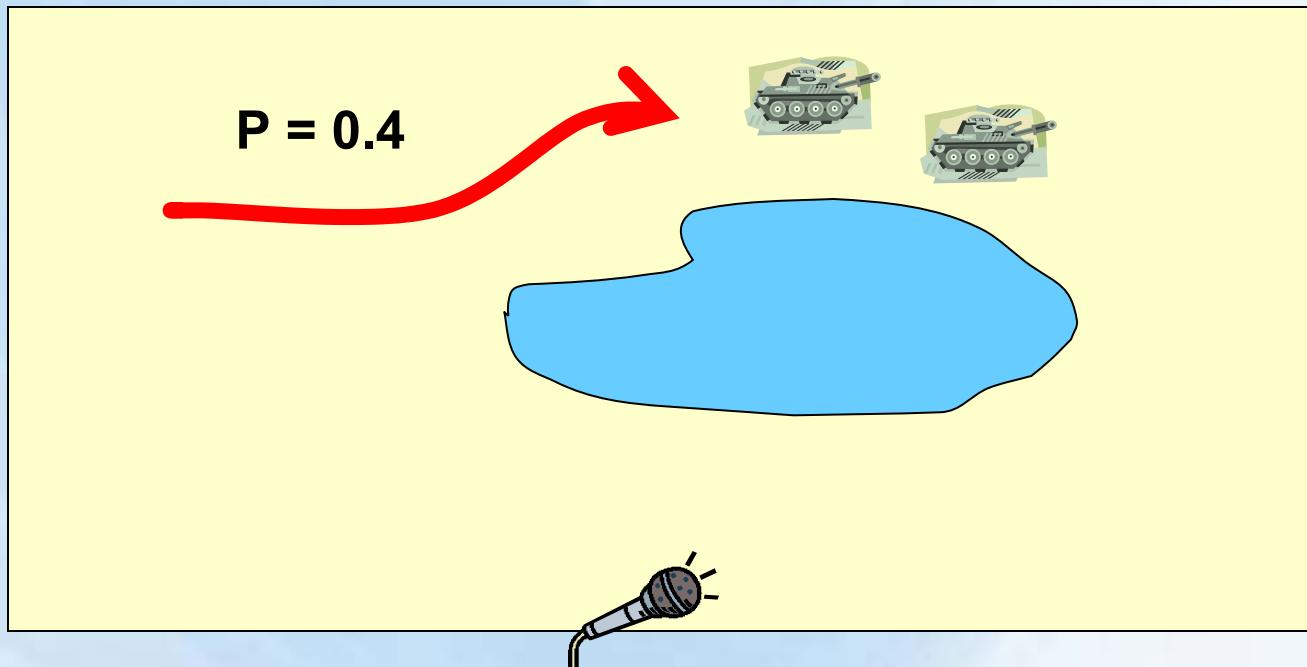


- **PROBLEM:** Given positions and possible strategies for the enemy, find an optimal sensor control policy
- **SOLUTION:** Evaluate sensor allocations by simulating different futures

Enemy positions now

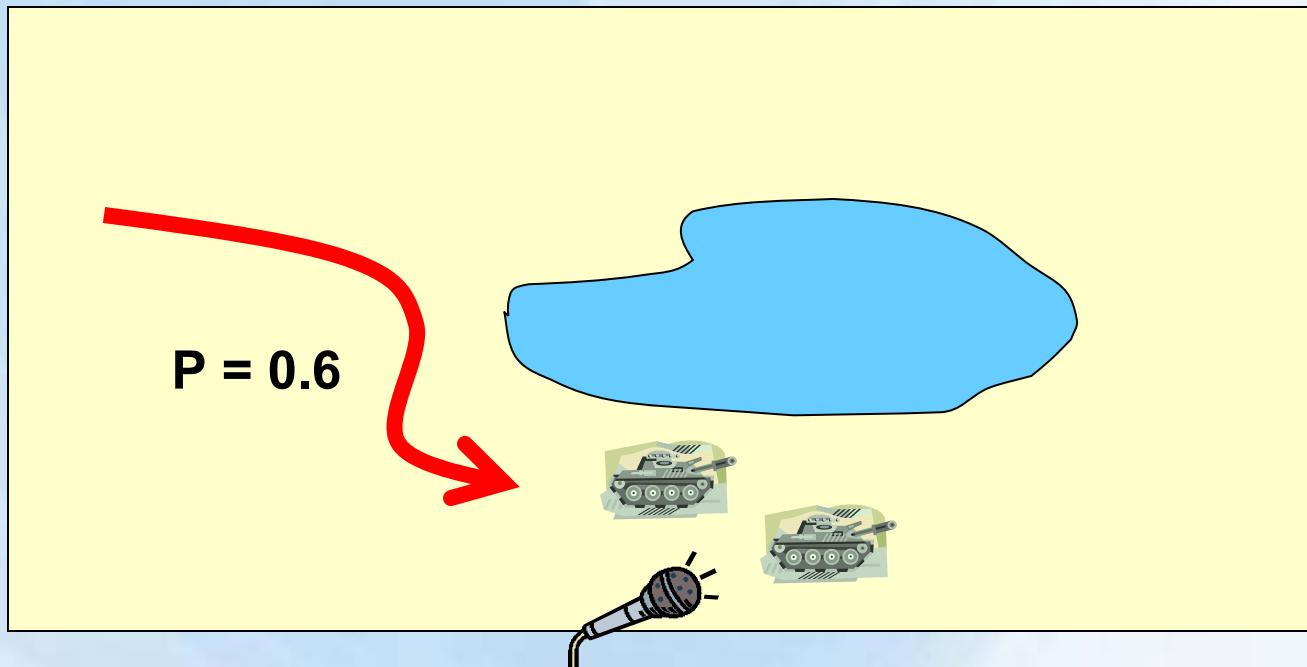


One possible future path



Sensor doesn't hear tanks!

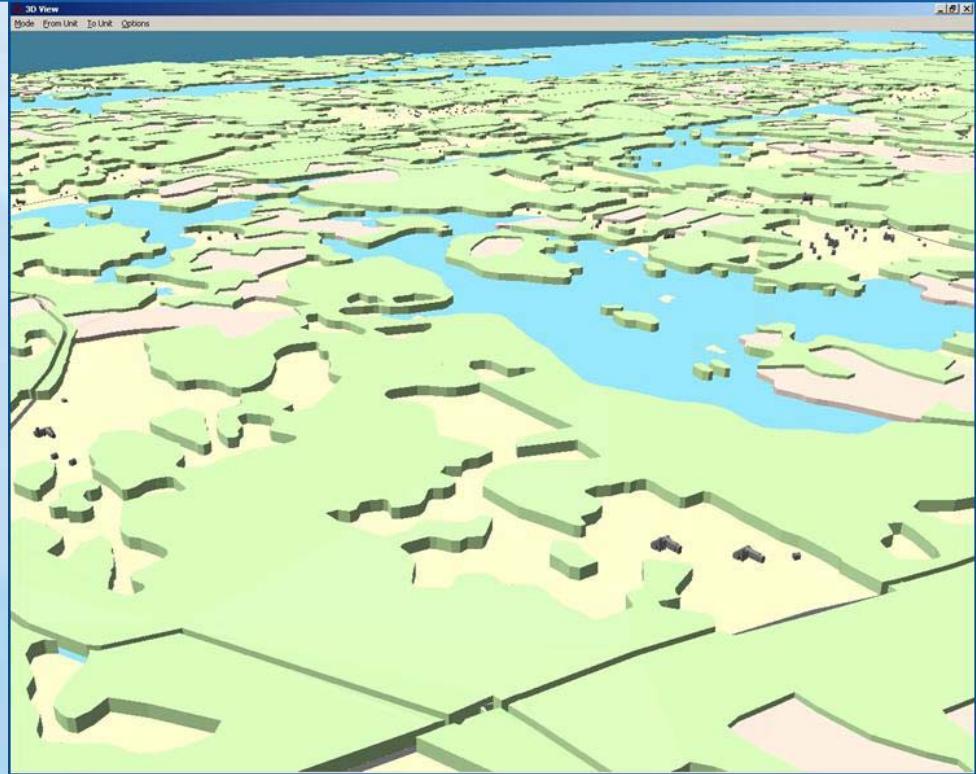
Another possible future path



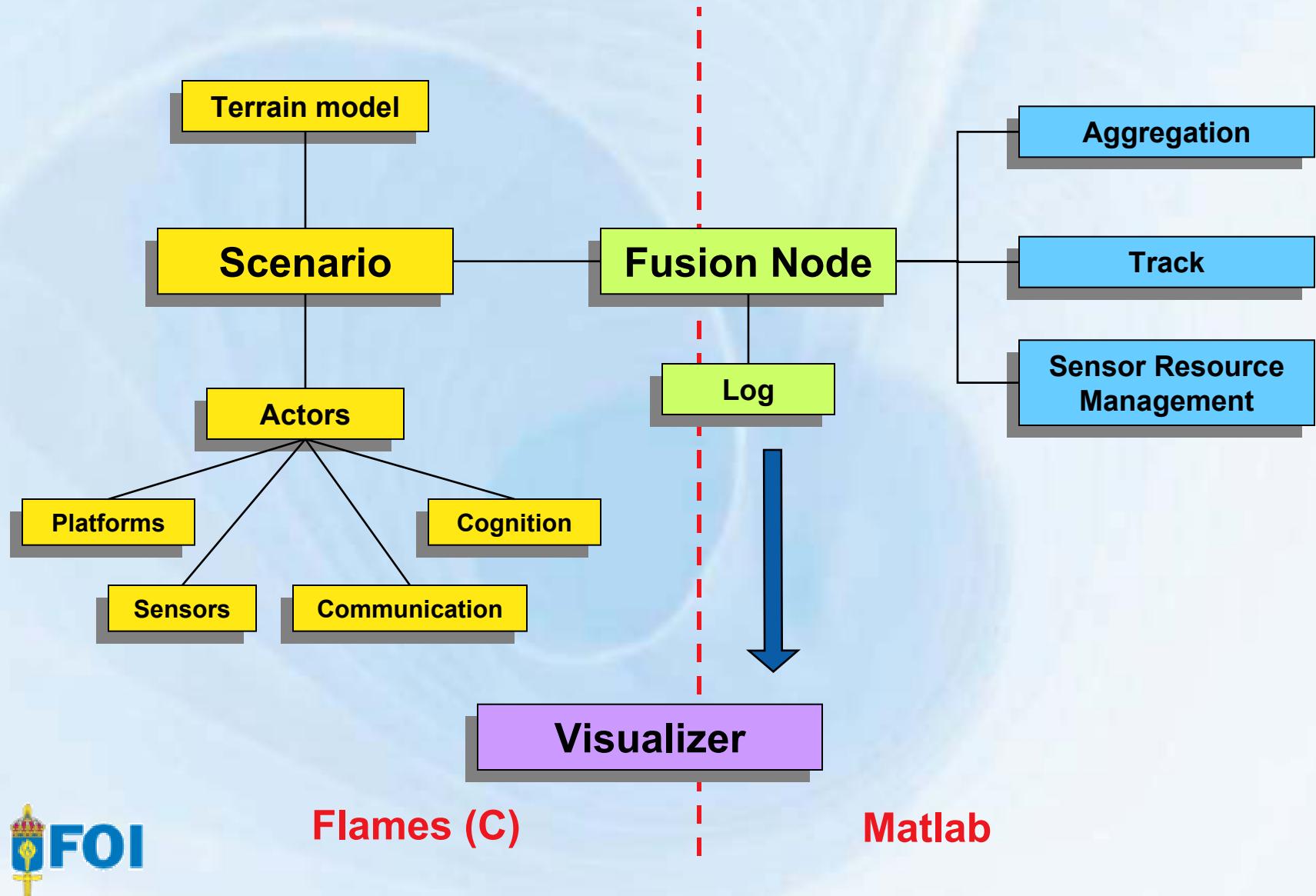
Sensor Resource Management

- Compare pre-determined sensor allocations
- Best sensor allocation is determined by averaging over many possible future paths

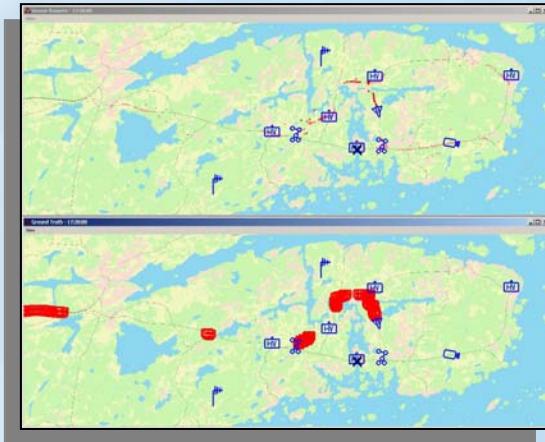
System Description



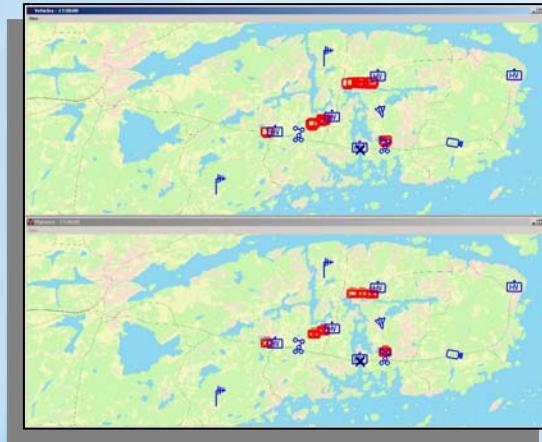
- **Simulation Framework (Flames)**
- **Terrain model generator (Terra Vista)**
- **Analysis methods implemented in Matlab**



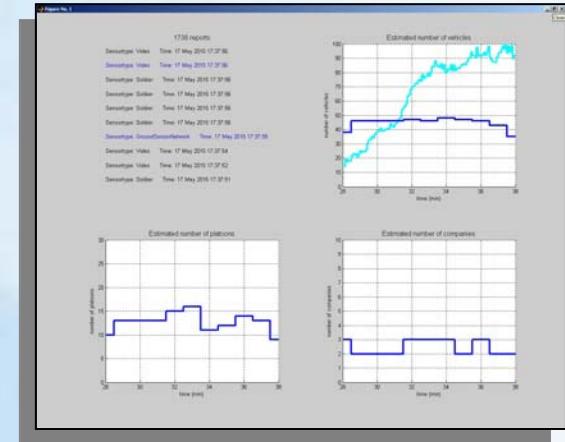
Visualizer



Intelligence/ Ground truth



Aggregation/ Track



Parameters/ Sensor Management

Conclusion

- We have developed a concept demonstrator for information fusion methodology
- Focus on intelligence processing at the division level
- A demonstration of IFD03 in December 2003 for the Swedish Armed Forces was a great success

Questions?

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